

channel device comprising the steps of providing a plastic substrate with a microchannel formed therein. The microchannel has one or more spatial dimensions in the micrometer-size range. When the polymer surface has a net negative charge, selected surfaces of the microchannel are exposed to a first solution comprising positively charged polyelectrolytes. If positively charged, the first solution is negatively charged polyelectrolytes. In the first case, the selected surfaces of the microchannel are exposed to a second solution comprising negatively charged polyelectrolytes. The steps of exposing the selected surfaces of the microchannel to the first solution and exposing the selected surfaces of the microchannel to the second solution are repeated, alternatively, as necessary, to form a desired number of polyelectrolyte layers on the selected surfaces.

The present invention, according to yet another aspect thereof, concerns a microchannel device comprising a plastic substrate having a microchannel formed therein. The microchannel has a first microchannel wall portion and a second microchannel wall portion. A polyelectrolyte layer is disposed as an outermost surface on the first microchannel wall portion and a second polyelectrolyte layer of opposite charge is exposed as an outermost surface on the second microchannel wall portion. A lid is disposed over the microchannel and has a lid surface facing the microchannel. The lid may be applied before or after deposition of the polyelectrolytes.

According to another aspect of the present invention, a method of manufacturing a microchannel device comprises the steps of providing a plastic substrate with a microchannel formed therein. At least one polyelectrolyte layer is formed on selected surfaces of the microchannel by exposing a selected portion of a first microchannel wall surface and a selected portion of the second microchannel wall surface of the microchannel to a first solution comprising first charge polyelectrolytes. The selected portion of the first microchannel wall surface is selectively exposed to a second solution comprising second charged polyelectrolytes. The second charged polyelectrolytes have a charge opposite a charge of the first polyelectrolytes.

One key feature of the present invention relates to altering the charge on the surfaces of a microchannel via PEM derivatization. Through PEM derivatization of a variety of different substrate materials which have different native EOF mobilities, similar EOF rates now can be achieved in microchannels formed in a variety of different materials. Thus, the present invention provides the advantage of the use of different materials while maintaining a similar EOF rate which was not easily achieved using underivatized (i.e., native) plastic materials.

Another feature of the use of PEMs according to the present invention is to create a microchannel with positively charged microchannel surfaces and negatively charged microchannel surfaces. Since the direction of the EOF fluid flow is determined by surface charge on the walls of a microchannel, PEMs can be used to control the direction in which an EOF fluid moves in a microchannel of a microfluidic device.

Still another feature of the present invention relates to providing a microchannel that allows flow of a fluid in opposite directions in the same microchannel. This may be achieved by derivatization of opposite sides of a plastic microchannel with oppositely charged polyelectrolytes to achieve side-by-side opposite flows. Alternatively, top-bottom opposite flows may be achieved by having a positively derivatized plastic substrate with a negatively charged lid or visa versa.

A further feature of relatively complex flow patterns may be provided by implementing the present invention to selectively apply various charged layers to selected surfaces, or portions of a microchannel, in a microchannel device. For example, the present invention can be implemented to produce a microchannel comprising different arms having surfaces of opposite charges.

Another feature is to increase biocompatibility of plastic microchannels in a generic way using PEMs.

A further feature of the present invention relates to enhanced wettability of microchannels derivatized using PEMs. As a result, priming the microchannel before introducing a fluid sample becomes unnecessary. Further, air bubbles are less likely to get pinned on the microchannel surface of the derivatized microchannels.

Yet another feature of the PEMs coated microchannel walls of the present invention is the ability to attach other molecules to the microchannel wall. Such immobilization allows for attachment or entrapment of molecules such as proteins, antibodies and DNA to the walls of a microchannel formed in a variety of substrates.

Further features and advantages of the present invention will be set forth in, or apparent from, the detailed description of preferred embodiments thereof which follows.

#### BRIEF DESCRIPTION OF THE DRAWING

FIG. 1(a) is a cross-sectional view of a microfluidic device having a PEMs derivatized multichannel according to the present invention;

FIG. 1(b) is a top view of the microchannel device of FIG. 1(a);

FIG. 1(c) is a top view of a microfluidic device having a cross-shaped microchannel design according to the present invention;

FIG. 2(a) is a top view depicting laminar flow in a microfluidic device having a "T"-shaped microchannel design used to selectively deposit polyelectrolyte layers in a single half of the microchannel;

FIG. 2(b) is a top view of the microfluidic device depicted in FIG. 2(a);

FIG. 2(c) is a cross-sectional view of the microchannel depicted in FIG. 2(a); and

FIGS. 3(a)–3(e) are top views of various cross-shaped microchannels schematically depicting fluid flow therein.

#### DETAILED DESCRIPTION OF THE INVENTION

Referring now to the figures, and in particular, to FIGS. 1(a) and 1(b), microfluidic device 10 comprises a plastic substrate 12. The plastic substrate 12 may be composed of any suitable plastic or polymer material which includes but is not limited to polystyrene (PS), poly(ethylene terephthalate glycol) (PETG), poly(methyl methacrylate) (PMMA), and polycarbonate (PC).

A microchannel 14 formed in substrate 12 has a trapezoidal cross-section defined by slanted sidewalls 16, 18. Alternatively, the side wall surfaces of the microchannel 14 could be substantially perpendicular to a bottom surface 20. Alternatively, the microchannel could have sloped side walls, straight side walls without a well defined floor (V groove) or curved, semicircular side walls forming a "U-shaped" groove, or any other configuration with a channel that has one or more spatial dimensions in the micrometer size range. The depth of microchannel 14 is between 0.05